Amendments to the Specification:

Please amend the specification as follows:

Please replace the paragraph on page 1, lines 12-14 with the following paragraph:

1. Field of the Invention

The invention relates to the field of semiconductor processing of films and in particular to processing nonsilicon films ~~on heterostructures~~.

Please replace the paragraphs on page 2, lines 11-18 with the following paragraph:

The invention is a method of forming a virtual substrate comprised of an optoelectronic device substrate and handle substrate comprising the steps of: initiating bonding of the device substrate to the handle substrate; improving or increasing the mechanical strength of the <u>bond between the</u> device and handle substrates; and thinning the device substrate to leave a single-crystal film on the virtual substrate such as by exfoliation of a device film from the device substrate.

The method further comprises the step of providing pre-bonding treatment to allow <u>for</u> the removal of a thin film.

Please replace the paragraph on page 2, line 21 to page 3, line 3 with the following paragraph:

The step of providing a pre-bonding treatment to allow the removal of a thin film comprises the step of ion implanting the device substrate to inject an amount of gas species into the device substrate to form [the] internally passivated surfaces and to create an internal pressure necessary to exfoliate a layer from the device substrate upon annealing. In the illustrated

embodiment ion implanting the device substrate comprises implanting H^+ or a combination of H^+ and He^+.

Please replace the paragraph on page 3, lines 4-16 with the following paragraph:

The step of cleaning and/or passivating the device and handle substrates to facilitate bonding comprises passivating the surface of both the device and handle substrates to allow hydrophobic wafer bonding. The step of passivating the surface of both the device and handle substrates comprises the step of enabling the formation of an intimate covalent bond between a device film, exfoliated from the device substrate, and the handle substrate in the virtual substrate to allow for the ~~ohmic~~ low-resistance interface electrical properties. The step of cleaning and/or passivating the device and handle substrates to facilitate bonding comprises the step of eliminating adsorbed water on the surface of the device and handle substrates by means of a low temperature bake in an inert atmosphere or in vacuum. The step of eliminating adsorbed water on the surface of the device and handle substrates by means of a low temperature bake comprising baking at a temperature such that the vapor pressure of water is ~~below~~ above the partial pressure of water in the surrounding ambient.

Please replace the three consecutive paragraphs on page 4, line 12 to page 5, line 10 with the following paragraphs:

The step of initiating bonding of the device substrate to the handle substrate comprises the step of controlling the temperature at which the device and handle substrates are brought into contact with each other to select the strain state, whereby substrate performance in high-temperature processes is improved, or a device operation temperature strain selected to adjust a device property such as bandgap or carrier mobility. The step of initiating bonding of the device

substrate to the handle substrate comprises the step of holding the temperature of the device and the temperature of handle substrate ~~substrates~~ when brought into contact with each other at different magnitudes to select the strain state.

In one embodiment, after initiating bonding of the device substrate to the handle substrate, the mechanical strength of the bond [of] between the device and handle substrates is improved and the ion implantation layer transfer process is thermally activated during which uni-axial pressure is applied to the virtual substrate.

The mechanical strength of the bond between the device and handle substrates is improved by using multiple pressure-temperature increments, or continuously varying pressure-temperature combinations. In another embodiment the mechanical strength of the bond of the device to the handle substrate is improved by applying higher pressures to ensure better substrate-substrate contact at lower temperatures prior to exfoliation where the higher pressures would at higher temperatures subdue exfoliation, and then reducing the pressure to a lower level prior to annealing at higher temperatures so that exfoliation is uninhibited.

Please replace the paragraph on page 6 lines 12-13 with the following paragraph:

Fig. 1 is a block diagram ~~illustrated~~ illustrating two alternative fabrication strategies for a virtual substrate.

Please replace the paragraph on page 7, lines 9-10 with the following paragraph:

Fig. 9 is a graph of the strain state as a function of temperature for [an] a GaAs/Si wafer bonded virtual substrate.

Please replace the paragraph on page 9, lines 8-13 with the following paragraph:

The materials of interest for device substrate 10 for the discussion below can be considered all materials that are relevant to wafer bonded virtual substrate device film materials for opto-electronic, high-gain device fabrication as ~~diagrammatically~~ illustrated diagrammatically in Fig. 2: III/V compound semiconductors (i.e. GaAs, InP, GaN, etc.), II/VI semiconductors (i.e. CdTe, etc.), group IV semiconductors (i.e. Ge for GaAs family growth), and optically important Ferroelectric oxides (i.e. $LiNbO_4$, $BaTiO_4$, etc.).

Please replace the paragraph on page 9, line 18 to page 10, line 12 with the following paragraph:

A generic process for fabricating such virtual substrates 16 comprises the following steps:

1) The device substrate 10 and handle substrate 14 may need pre-bonding treatment to allow <u>for</u> the removal of a thin film 12 (~~i.e.~~ <u>e.g</u>.. ion-implantation <u>into device substrate 10</u> as diagrammatically depicted <u>by number 11</u> in Fig. 3a).

2) The device substrate 10 is cleaned and/or passivated to facilitate bonding.

3) Bonding is initiated as diagrammatically shown in Fig. 4a.

4) The bond <u>42</u> is strengthened ~~to improve the mechanical strength of the device substrate 10 and handle substrate 14~~.

5) The device substrate 10 is thinned to leave a single-crystal film 12 on the finished virtual substrate 16 as shown in Fig. 4b for an ion-implanted substrate.

6) In the case of ion implantation induced layer exfoliation, the device substrate 10 from which the device film 12 was derived can be reprocessed by a means of

surface polishing to allow the reuse of the substrate 10 to transfer another device film as illustrated in Fig.[4b] 5a and Fig. 5b.

Please replace the paragraph on page 12, lines 14-23 with the following paragraph:

Following implantation and prior to bonding, it is necessary to passivate the surface of both the device and handle substrates 10, 14 to allow hydrophobic wafer bonding. The specific chemical process necessary is device substrate specific. The purpose of this step is to enable the formation of an intimate covalent bond between the device film 12 and handle substrate 14 in the finished virtual substrate 16 allowing for the possibility of ohmic, low-resistance interface electrical properties. A necessary step in enabling this finished device structure will be the elimination of adsorbed water on the surface by means of a low temperature bake in an inert atmosphere or in vacuum. The bake should reach a temperature such that the vapor pressure of water at that temperature is well ~~below~~ above the partial pressure of water in the surrounding ambient.

Please replace the paragraph on page 14, lines 3-14 with the following paragraph:

Another enabling technology for extending this process to a wide range of optoelectronic materials is the use of a deposited surface modification layer ~~18~~ 40 of arbitrary thickness to change the nature of the physical interaction between the substrates 10, 14 as depicted in Figs. 6a and 6b. This can be done in one of three ways, where X stands for any type of composition compatible with the disclosed method:

a. Deposition of a layer ~~18~~ 40 of material X on the device substrate 10 to enable an X-handle material bond.

b. Deposition of a layer ~~18~~ 40 of material X on the handle substrate 14 to enable an X-device material bond.

c. Deposition of a layer ~~18~~ 40 of material X on both substrates to enable an X-X bond.

Please replace the paragraph on page 14, lines 15-24 with the following paragraph:

This technology enables the integration of a wide range of optoelectronic materials by mastering bonding with a material which is compatible or amenable ~~amendable~~ to the disclosed process, which for the moment is ~~refernenced~~ referenced simply as material X. The generic process is illustrated in Figs. 6a and 6b. Fig. 6a illustrates the surface modification of the implanted device substrate with either a crystalline or amorphous film 40 of the same chemical identity as the handle substrate 14. Fig. 6b illustrates a wafer bonded substrate stack using this technique showing the device substrate 10, the ion implanted damage region 13, the device thin film 12, the deposited bond mediating film 40, the bonded interface 42, and the handle substrate 14.

Please replace the paragraph on page 15, line 21 to page 21, line 12 with the following paragraph:

Following surface passivation, it may be necessary to remove residual particle contamination on the bonding surfaces of the device and handle substrates 10 and 14. This has been efficiently done by performing a clean with a CO_2 particle jet [20] as depicted in Figs. 4a and 4b. Fig. 4a is a diagram of a device substrate 10 and handle substrate 14 stack following ion implantation and initial bonding, showing the undamaged bulk device substrate 10, the ion implanted damage layer 13, the device thin film 12, the wafer bonded device/handle interface 42,

and the handle substrate 14. Fig. 4b is a diagram showing the wafer bonded virtual substrate 16 following the anneal and layer exfoliation, and showing the undamaged bulk device substrate 10 with its ion implanted damaged surface region 13. Also shown is the wafer bonded virtual substrate 16 comprised of the ion implantation damaged surface region 13 of the device film 12, the undamaged transferred device film 12, the wafer bonded interface 42, and the handle substrate 14. The substrates 10 and/or 14 [is] are held at an elevated temperature and a throttled gas/particle jet of CO_2 is impinged on the surface of substrates 10, 14 removing particles by a combined physical impact and thermophoretic lifting effect.

Please replace the paragraph on page 22, lines 15-19 with the following paragraph:

Following the transfer of the device ~~layer 10~~ film in the ion implantation induced layer transfer process, the near surface region of the device film 12 is both rough and defect rich. This layer must be controllably removed to leave a surface that is useful for subsequent processing to fabricate an optoelectronic device as shown in Figs. 11a and 11b. Depending on the device layer 10 this can be accomplished by:

Please replace the paragraph on page 24, lines 12-19 with the following paragraph:

The finished virtual substrate 16 is meant to serve as a template for growth of an optoelectronic device through hetero-epitaxy. Through careful device layer modification, epitaxy of a wide range of optoelectronic devices is made possible. A representative image of such a structure is shown in Figs. 13a and 13b. Fig. 13a is a diagram which shows the completed wafer bonded virtual substrate 16 comprised of a thin device film 12, a wafer bonded interface 42 and a

handle substrate 14. Fig. 13b is a diagram which shows a wafer bonded virtual substrate 16 with an epitaxially grown device [40] 50 fabricated on the device thin film 12.

Please replace the paragraph on page 24, line 23 to page 25, line 8 with the following paragraph:

One potential challenge in implementing wafer bonded virtual substrates in the fabrication of devices in or on the transferred layer by standard processing such as MOCVD, diffusion, implantation, and lithography is the possibility of wafer bow due to the presence of thermal expansion derived strain in the transferred layer. A practical approach to minimizing this effect would be to deposit a strain compensation layer on the back surface of the handle substrate 14 as shown in Fig. 14. Fig. 14 is a diagram which schematically shows an optoelectronic structure [40] 50 grown on a wafer bonded virtual substrate 16 comprised of the device film 12, the bonded interface 42, the handle substrate 14, and a strain compensation layer 18 deposited on the back surface of the substrate.